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NCTS# 25415-17 AGU 2016

Linking remotely sensed aerosol types to their chemical composition

Aerosol types measured during the Ship-Aircraft Bio-Optical Research (SABOR) experiment are related to GEOS-Chem model chemical composition. The application for this procedure to link model chemical components to aerosol type is desirable for understanding aerosol evolution over time. The Mahalanobis distance (D_M) statistic is used to cluster model groupings of five chemical components (organic carbon, black carbon, sea salt, dust and sulfate) in a way analogous to the methods used by *Burton et al.* [2012] and *Russell et al.* [2014]. First, model-to-measurement evaluation is performed by collocating vertically resolved aerosol extinction from SABOR High Spectral Resolution LiDAR (HSRL) to the GEOS-Chem nested high-resolution data. Comparisons of modeled-to-measured aerosol extinction are shown to be within 35% ± 14%. Second, the model chemical components are calculation into five variables to calculate the D_M and cluster means and covariances for each HSRL-retrieved aerosol type. The layer variables from the model are aerosol optical depth (AOD) ratios of (i) sea salt and (ii) dust to total AOD, mass ratios of (iii) total carbon (i.e. sum of organic and black carbon) to the sum of total carbon and sulfate (iv) organic carbon to black carbon, and (v) the natural log of the aerosol-to-molecular extinction ratio. Third, the layer variables and at most five out of twenty SABOR flights are used to form the pre-specified clusters for calculating D_M and to assign an aerosol type. After determining the pre-specified clusters, model aerosol types are produced for the entire vertically resolved GEOS-Chem nested domain over the United States and the model chemical component distributions relating to each type are recorded. Resulting aerosol types are Dust/Dusty Mix, Maritime, Smoke, Urban and Fresh Smoke (separated into 'dark' and 'light' by a threshold of the organic to black carbon ratio). Model-calculated D_M not belonging to a specific type (i.e. not meeting a threshold probability) is termed an outlier and those D_M values that can belong to multiple types (i.e. showing weak probability of belonging to a specific cluster) are termed as Overlap. MODIS active fires are overlaid on the model domain to qualitatively evaluate the model-predicted Smoke aerosol types.

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